



Operating and Service Manual

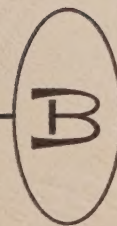
MODEL 110A

GAUSSMETER

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ELECTRONIC DESIGN • DEVELOPMENT • MANUFACTURING



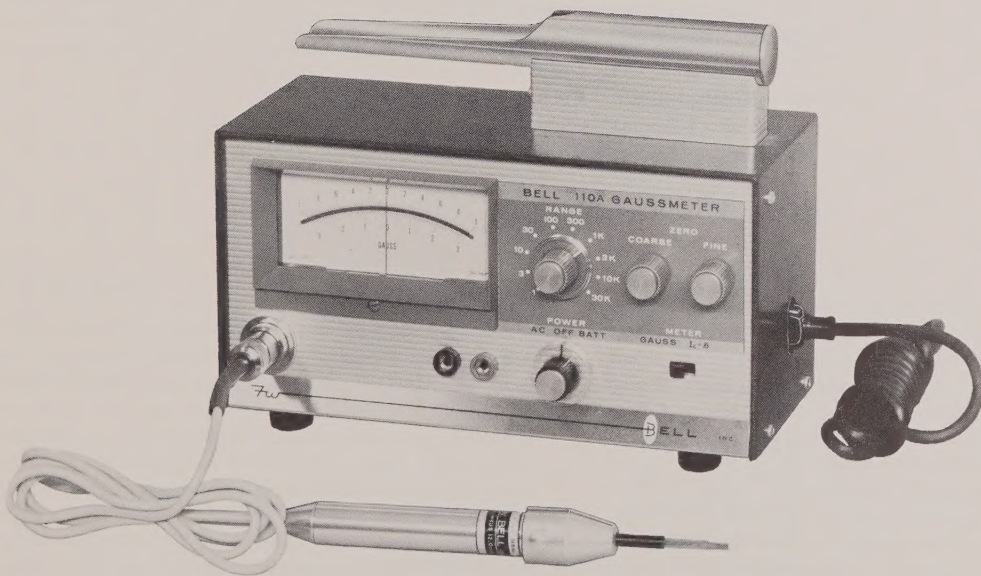
BELL INC.
COLUMBUS, OHIO



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MODEL 110A

GAUSSMETER



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ELECTRONIC DESIGN
DEVELOPMENT • MANUFACTURING

B

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SECTION I
SPECIFICATIONS
MODEL 110A GAUSSMETER

SENSITIVITY RANGE -

1 gauss to 30,000 gauss in ten ranges. Full scale readings in gauss of:

1	300
3	1,000
10	3,000
30	10,000
100	30,000

ACCURACY -

±2% of full scale plus accuracy of reference magnet up to 10,000 gauss. Calibration curve used above 10,000 gauss. Approx. ±3% of full scale up to 10,000 gauss when using built-in calibration feature. Accuracy at calibration points depends on accuracy of reference magnets used; 0.5% magnets are available from F. W. Bell, Inc.

FREQUENCY RESPONSE -

The meter reads only D.C. fields and is direction sensitive. A.C. fields up to 400 cps can be measured at the output jacks using an oscilloscope or other

external indicator. See frequency response curve Fig. III-2.

OUTPUT -

A D.C. voltage proportional to meter reading is available at the output jacks; 100 millivolts ±10% at full scale. Output impedance approximately 10,000 ohms. A.C. response as indicated above. Will drive most servo-type recorders directly.

POWER SUPPLY -

Internal mercury batteries, 1000 mah rating. Normal life expectancy, 100 hrs. A.C. operation - 115/230 volts; 50/60 cycles.

DIMENSIONS -

8¼" high, 10⅞" wide, 6" deep, overall.

WEIGHT -

Net 6½ lbs., shipping 9½ lbs. less probe. Add 1 lb. for probe.

SECTION II
GENERAL DESCRIPTION

II-1 GENERAL

The Model 110A Gaussmeter is a precision magnetic flux measuring instrument. It operates from the "Hall-Effect" probes made by F. W. Bell, Inc. and designed for use with Model 110A. It has been designed for maximum portability, ease of operation and most efficient use of battery power. High accuracy has been obtained over a wide range of sensitivities from 20 milligauss per scale division on the lowest range to 10,000 gauss full scale. The area from 10,000 gauss to 30,000 gauss on the high range is subject to slightly reduced accuracy, unless a calibration curve or reference magnets are used (not normally supplied).

Various types and sizes of field probes are available for the Model 110A. Interchangeability from one probe to another is rapidly accomplished via the front panel connector and a simple re-calibration procedure described later. Direction as well as

amplitude information of magnetic fields is obtained, and polarity reversals in D.C. fields is observed as meter deflection changes to left or right of zero center. The Hall-Effect probes are sensitive only to the component of magnetic field which is at right angles to the face of the Hall sensing element. Hence rotating the probe in the field will result in varying meter indications. This characteristic is valuable when tracing and plotting magnetic fields. D.C. as well as A.C. fields up to 400 cps can be observed and measured directly from the output jacks on the front panel using an external indicator. Useful readings can be obtained up to 1000 cps. The instrument is completely transistorized using standard transistor types and is temperature compensated and stabilized for operation over a wide range of environmental conditions.

Although operation is practically instantaneous after turn-on, approximately 2 to 10 minutes is re-

quired for complete stabilization to occur, depending upon the length of time the unit has been inoperative. The batteries are 1000 mah units and normal life is 60 hours for the oscillator section battery and 250 hours for the amplifier battery. Maximum life will be obtained by interchanging the batteries after 50 hours in which case discharge will equalize and both batteries will give 100 hours life. Only type TR-136-R batteries should be used.

II-2 CONTROLS & CONNECTORS

A. FRONT PANEL

The front panel contains the indicating meter, the probe input connector socket, the COARSE and FINE zeroing knobs, power switch, meter switch, output jacks, and the range switch calibrated from 1 gauss to 30 KG (30,000 gauss) full scale.

ZERO

A 3-position power switch is provided for turning the unit off, or placing it on A.C. or battery operation, which ever is desired.

INPUT

The zero controls are used to balance the normal ohmic unbalance in the probe sensing element and to cancel the effects of stray fields so as to bring the meter to zero.

OUTPUT

The input receptacle on the left front accepts the probe cable plug.

OUTPUT

The output jacks accept a standard G.R. type double banana plug. The left hand jack (black) is at chassis potential. The voltage at the jacks is proportional to meter reading and is nominally 100 millivolts D.C. when the meter reads full scale. External A.C. or D.C. indicating instruments such as a V.T.V.M., oscilloscope or a recorder (servo

type), can be operated from the output jacks. Source impedance is 10K ohms.

B. REAR PANEL (Refer to Fig. V-1)

CAL

A cut-out in the rear panel permits access to the calibrate switch S2 and gain control R35 used to calibrate the instrument. Operation of these is described later.

CONTROL CURRENT ADJUST

Also, facing the rear, two entrance holes will be noted along the lower right hand portion. These are slotted adjustments for entrance of a thin-blade screwdriver. The extreme right hand adjustment is the probe control current I_c (R-38).

ELECTRICAL ZERO

The other (R-37) is for adjusting electrical zero on the meter under zero field conditions.

II-3 POWER

The power cable supplied has three conductors and is terminated in a three-prong plug recommended by the National Electrical Manufacturers' Association. The round pin is connected to the chassis and grounds the instrument case and output terminals when used with the appropriate receptacle. An adapter may be used for connection to a standard two-contact receptacle. The ground is brought out of the adapter by means of a short wire which should be connected to a suitable ground for protection of operating personnel. Only when a ground is supplied by associated equipment should this ground be unused to prevent common ground currents.

The Model 110A is normally wired for operation from a 117 volt, 50-60 cps power source. To convert it for 234 volt 50-60 cps operation the dual primary of the power transformer is changed from parallel to series connection. Refer to the schematic diagram for details.

SECTION III OPERATION INSTRUCTIONS

III-1 PROBE HANDLING

CAUTION

The sensing elements used with the Model 110A are extremely thin and fragile and can easily be permanently damaged. Special care should be exercised in handling the transverse probes, such as the T-1101, which allow exposure of the thin sensing element for measurements in narrow gaps. To expose

the element, rotate the outer protective tube counter-clockwise (about 30 degrees). This releases the safety catch and allows the tube to be pushed back into the handle. Always restore the outer tube to the protective position when not actually making narrow gap measurements. The safety catch will automatically engage when the tube is pulled out to its extreme position and released. Axial probes, such as the A-1101, are not as fragile as the trans-

verse probes and have no protective tube.

The sensing element used in all probes is strain sensitive and no forces should be applied directly against it during measurement. Also, it should be protected from temperature shock, such as touching against hot or cold objects. High temperature environments, rapid thermal changes, or high velocity air flow over the element can also result in apparent drift of the zero setting on the lower ranges, and should be avoided.

No attempt should be made by the user to repair or modify the probe assembly, in any way. The probe cable is of special design and its terminations in the cable plug and probe handle are very precisely adjusted to cancel out quadrature voltages which would cause overload and non-linear operation on the lower ranges.

If needed, probes with longer cables can be obtained on special order.

III-2 INITIAL CHECKS

Before turning the unit on a probe should be connected to the front panel input connector. Push the plug firmly into the socket until completely seated then screw in the outer clamp ring snugly. Make certain that the meter indicates zero; if not, adjust the centering screw on the front of the meter case.

III-3 TURNING ON

The power switch is a 3-POSITION switch as follows:

Left position – ON – A.C. operation.

Center position – OFF – batteries and AC line disconnected.

Right position – ON – battery operation.

CAUTION – Always turn power switch OFF after use. Do not turn off by pulling power cord, as regulator battery will be on discharge.

First switch to I_c position, then place the power switch in the A.C. or BATT position, whichever kind of operation is desired. If the probe is plugged in, the meter will indicate in proportion to the probe control current. The purpose of this reading is:

- (a) To insure that the probe is carrying correct current – a reading of .6 on the upper scale is correct, and,
- (b) As an indication of battery condition, when battery operation is being used. When this reading falls by 10% or more below the original value on a particular probe, the batteries probably need replacement. Allow 1 to 5 minutes

for stabilization to final reading.

III-4 PROBE CONTROL CURRENT (I_c) ADJUSTMENT

If the unit has not been previously adjusted for the particular probe to be used, the probe current I_c reading may need adjustment to the correct value of .6 on the upper dial scale. An adjusting screw R38 is provided thru an entrance hole in the rear panel. Allow a few minutes for stabilization, then insert a thin-blade screwdriver into the extreme right hand entrance hole in the rear panel – viewed from the rear. Gently feel for the slot in the adjusting screw and insert the screwdriver blade. **ADJUST FOR .6 READING ON UPPER SCALE.**

III-5 ZERO ADJUSTMENTS

Now make certain that the RANGE switch is set to the highest (30 KG) range position. Then place the meter switch in the Gauss position. The meter should now indicate zero unless the probe is located in a strong magnetic field (or unless the OPERATE – CAL switch located on the rear of the instrument has been erroneously left in the CAL position).

NOTE: Each probe requires separate zero adjustment and calibration (described below).

First adjust the COARSE ZERO knob while reducing the range switch to lower ranges. Use the FINE ZERO knob to obtain a precise zero on the 3 gauss and 1 gauss ranges. Do not turn the COARSE ZERO knob on these low ranges.

The above zeroing procedure can be carried out rapidly and without “banging the meter.” Although meter protection is designed into the circuitry, the meter can still be damaged by sudden and severe overloads and they must be avoided.

It is important to note that this instrument has sufficient sensitivity to respond to the earth's magnetic field so that a zero adjustment made in the presence of the earth's field, or other stray fields, will be affected by, and included in, the zero setting. A Zero Gauss Chamber (F. W. Bell, Inc. Model YA-111) is recommended in order to obtain a true zero reading.

Note that clockwise rotation of the zero knobs will result in upscale pointer deflection.

Now return to the 30K RANGE position. The meter should read exactly zero. If not, the detector balance control R37 (rear panel, adjacent to I_c adjustment hole) can be adjusted for meter zero.

III-6 CALIBRATION PROCEDURE

Each probe used with the Model 110A has slightly different sensitivity and as a result, a gain calibration adjustment must be made on each probe to com-

pensate for the particular probe output.

This procedure must be carried out each time a probe is changed. The probe is calibrated by either one of two methods:

- (a) Calibration against a reference magnet.
- (b) Calibration using the probe CAL CONSTANT.

A. CALIBRATION AGAINST A REFERENCE MAGNET

Reference magnets are supplied by F. W. Bell, Inc. in various sizes. They are highly stabilized precision magnets designed to provide a known magnetic field for calibration purposes. This is the most accurate method of calibration.

1. Follow the procedure already described for adjustment of probe current I_C and the zero procedure. A zero gauss chamber or suitable mu-metal can must be used when calibrating against a 100 gauss (or lower value) reference magnet.
2. Set the RANGE switch to the proper value for the rating of the magnet used. Using care and observing precautions already described, insert the probe into the magnet and position carefully for MAXIMUM READING. If the meter does not indicate the value of the calibration magnet, adjust the calibration gain control R35 located just inside the rectangular cut-out in the rear panel of the instrument.

This is a screwdriver slot adjustment which is rotated until the meter indicates exactly the calibration rating shown on the magnet nameplate.

NOTE: Calibration at one point, say 1 KG, will help to bring the gaussmeter into calibration on all ranges, within accuracy limits. However, best accuracy is obtained by calibrating at or near the field value where measurements are to be made.

B. CALIBRATION AGAINST PROBE CAL CONSTANT

The probe CAL CONSTANT is a calibration number marked on the probe nameplate. This number was obtained by measurement in the F. W. Bell, Inc. laboratories against reference magnets and may be inserted into the Model 110A Gaussmeter by a transfer method to be described below:

1. Carry out the probe current adjustment as described in Section III-4.
2. Set the RANGE switch to the 30K position. Move the OPERATE - CAL switch S2 located inside the rectangular cut-out in the rear panel to the CAL position. The meter should then indicate the CAL CONSTANT (reading the upper meter scale). if not, adjust the calibration gain control R35 located alongside the

switch until the meter indicates the value of the probe CAL CONSTANT. Return the switch to the OPERATE position, carry out the zero procedure and the instrument is ready for use, and is calibrated for that particular probe.

III-7 MAKING MEASUREMENTS

Magnetic field measurement techniques vary widely with the particular application. The following comments are intended to aid by describing the general characteristics of the Gaussmeter and probe.

A. THE PROBE

Two basic probe types are available for use with the Model 110A. They are characterized by the field direction to which the probe is responsive, i.e. transverse and axial.

Transverse probes measure the component of flux density B which is at right angles to the face of the sensing element. Axial probes measure the field component parallel to the axis of the probe stem itself. Since these probes are very small in size and of essentially non-inductive design, they will have negligible effect on the field being measured. They must, however, be carefully positioned within the field to read correctly. Since the probe responds only to the field component normal to the sensing element surface, it must be aligned exactly perpendicular to the field vector. This is easily accomplished by orienting for maximum meter reading.

IMPORTANT - Observe the precautions outlined at the beginning to avoid probe damage and to minimize possible measurement errors.

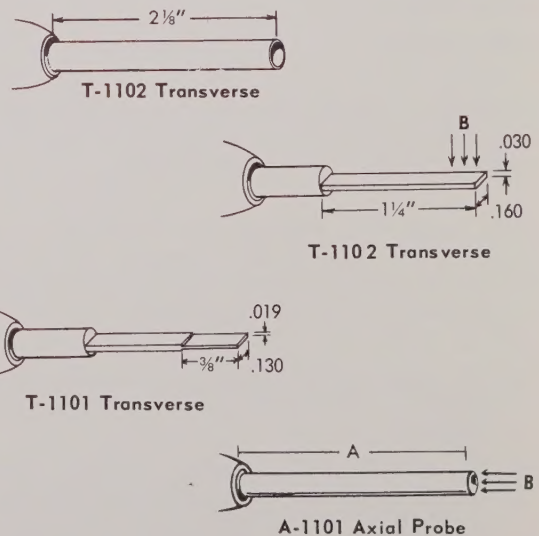


Fig. III-1 - Probes

B. LOW LEVEL MEASUREMENTS

When the Model 110A Gaussmeter is used on the lower ranges it will be observed that the earth's magnetic field (about $\frac{1}{2}$ gauss) will indicate on the meter. Zero adjustments made on the low ranges therefore include the effect of the ambient field in which the probe is immersed i.e., the background field is "bucked out" electrically by the zeroing controls on the Gaussmeter to bring the pointer to zero.

C. RELATIVE MEASUREMENTS

Under the above conditions the instrument has a "floating zero" and becomes a differentially reading unit. It will indicate correctly any incremental change in the background field or alterations due to an additional field to be measured.

Frequently these changes provide all the information that is needed, further, the method eliminates the need for elaborate and costly shielding. It is necessary, however, to maintain the probe absolutely stationary with respect to the ambient field in order that the zero setting remain fixed.

D. ABSOLUTE MEASUREMENTS

In order to obtain correct readings of absolute field strength, an absolute zero reference must be used. This is done by shielding the probe sensing element completely when making the zero adjustment. The F. W. Bell, Inc. Zero Gauss Chamber YA-111 is designed specifically for this purpose and will, by its unique design, provide adequate shielding of ambient fields up to about 100 gauss, and will reduce these fields well below the maximum sensitivity of the Model 110A. In the absence of a Zero Gauss Chamber or Mu-metal can for shielding, an approximate zero will be obtained by adjusting for equal ambient field readings in both directions as the probe is rotated for maximum readings. The probe can then be oriented to the center (zero) of these readings.

E. PLOTTING FIELD DIRECTION

The directional feature of the Hall-Effect sensing device can be used to advantage to obtain accurate direction information. A probe holding fixture may be used with provision for rotating a T-1101 transverse probe exactly 90° . After calibration and zeroing, the probe is placed in the unknown field and oriented to maximum reading.

It is then rotated about the probe axis for a zero reading, stepping the range switch to the lowest range for greatest sensitivity to angular position. At zero position, the sensing element will lay in a plane parallel to the field direction vector. Switching now to a suitable scale, the probe is rotated 90° and the field magnitude is read in Gauss.

When measuring or plotting curved fields, the tangential component of the field strength is indicated by the gaussmeter.

F. MEASURING D.C. FIELDS

The usual procedure in measuring D.C. fields is to orient the probe for a maximum reading on the meter. Always use the range that will give the highest meter reading. When using axial probes deep in a hole, it should be noted that only the field component along the axis of the probe will be indicated. When high field gradients are encountered, careful positioning of the probe is essential. In some cases the active area of the sensing element must be considered, the reading being approximately the average flux density integrated over this area.

G. MEASURING A.C. FIELDS

Alternating, pulsing or varying magnetic fields may be observed and measured by using a suitable external indicator connected to the output jacks. Since the Model 110A operates on a field modulated A.C. carrier system, there is a limitation on the maximum frequency that can be observed without interference with the 5KC carrier signal in the Gaussmeter.

An oscilloscope with about 200 millivolt sensitivity, connected to the output jacks on the front panel, will indicate field frequencies up to 400 cps with only a small amount (about 4 mv p-p) of 5KC carrier ripple showing. The filter in the Model 110A output begins attenuation above 400 cps, although readable results can be obtained to 1000 cps. The output response to A.C. fields is shown in Fig. III-2.

An oscilloscope with D.C. response can be easily calibrated to read A.C. fields directly, even though the front panel meter will not indicate A.C. fields. Proceed as follows:

- (a) Connect a shielded cable from the 110A output jacks to the oscilloscope D.C. vertical input.
- (b) Zero the Gaussmeter on the 10 gauss range and center the oscilloscope trace on the screen.
- (c) Adjust the Gaussmeter zero controls to give full scale deflection to the right, then place the meter switch in the I_c position to remove the meter from the measuring circuit.
- (d) Set the oscilloscope gain to move the trace to the top (or bottom) graticule line (negative output voltage for upscale right deflection).
- (e) Place the meter switch in the GAUSS position and adjust the zero controls for full scale left deflection. Then place the meter switch in the I_c position and observe that the oscilloscope trace moves an equal amount in the opposite direction.
- (f) Reset to zero on the meter and oscilloscope, then switch to I_c position for A.C. readings.

The oscilloscope is now calibrated so that full deflection of the beam corresponds to full scale value of flux density as would be read on the meter. The calibration will apply to any range on the Gaussmeter range switch. When reading A.C. fields the steady (D.C.) field components, if any, must be minimized to avoid amplifier overload.

This will be accomplished if the trace on the oscilloscope is kept centered by adjusting the Gaussmeter zero controls rather than the oscilloscope centering controls.

An A.C., V.T.V.M. may also be used along with the oscilloscope.

Keep in mind that a residual carrier voltage of about 1 to 1.5 millivolts at 5KC will be included in the readings unless an external filter is provided to reduce it.

A recorder can also be used in place of the oscilloscope, using the same method of calibration.

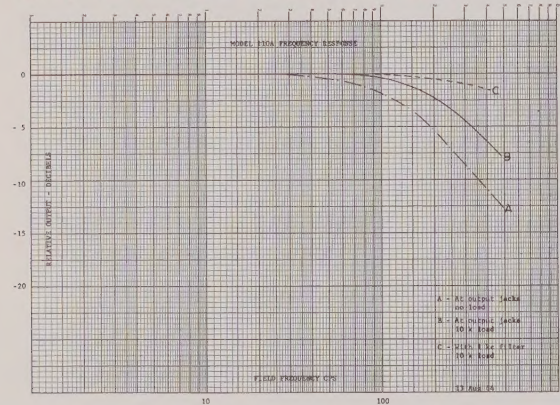


Fig. III-2 - Frequency Characteristic at Output Jacks, Model 110A

H. USE OF THE OUTPUT JACKS

1. The 5KC carrier ripple in the output signal should not exceed 2 mv RMS.
2. D.C. Voltage 100 mv $\pm$ 10% at full scale (negative).
3. Source impedance of output jacks 10 K Ω and loading loss can be figured on this basis.
4. Frequency response to A.C. fields see Fig. III-2.
5. Loading of output jacks affects meter reading as follows:

Load Resistance	Meter Reading Error
INF.	0
20 K Ω	1% reduction
10 K Ω	1.8% reduction
1 K Ω	3.8% reduction
0 Ω	4% reduction

6. To prevent output loading from resulting in calibration errors (when calibrating external read-out instrument), disconnect the load when adjusting the Gaussmeter and when reading actual flux density values. In oscilloscope calibration, disconnect load when adjusting for full scale deflection in steps (c) and (e) in paragraph G above.

III-8 CONDENSED OPERATING CHECKLIST

A. TO OPERATE

1. Connect probe
2. Check I_c (meter reading = .6 upper scale)
3. Zero adjust down to 1 gauss range (coarse to fine zero knobs)

B. TO CALIBRATE USING CAL CONSTANT

1. Carry out (A) above
2. Range switch to 30K position
3. Set CAL switch S-2 (rear opening) to CAL position
4. Adjust CAL screw R-35 (rear opening) to make meter read CAL number
5. Switch back to operating position

C. TO CALIBRATE AGAINST REFERENCE MAGNET

1. Carry out (A) above
2. Measure reference (calibrate) magnet
3. Adjust CAL screw R-35 (rear opening) for exact reading of magnet value

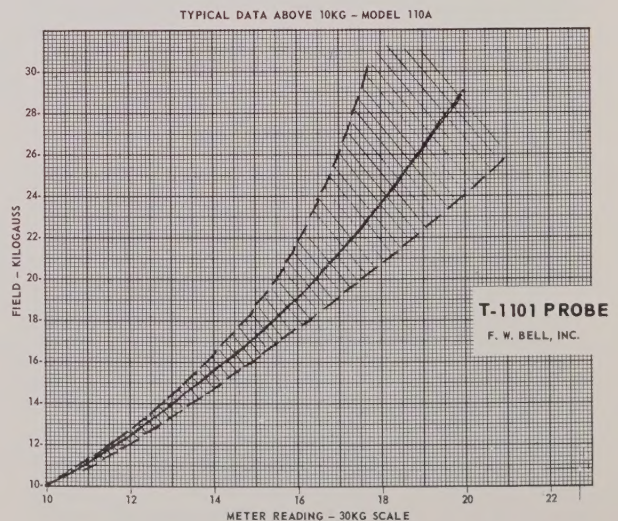


Fig. III-3 - Typical Data Above 10 KG - Model 110A

SECTION IV THEORY OF OPERATION

IV-1 GENERAL

Basically the Model 110A operates on a flux-modulated carrier signal system. The operating principle is quite similar to that of a D.C. chopper amplifier. The sensing element, fed with an A.C. exciting current, acts as the input chopper, providing an A.C. output voltage when placed in a D.C. magnetic field. The A.C. signal is amplified and then restored to D.C. by a synchronous demodulator. The D.C. output voltage drives the panel meter and is available at the OUTPUT jacks for operation of auxiliary instruments.

IV-2 SENSING ELEMENT

The sensing element is a semiconductor device operating on the Hall-Effect principle. It consists of a thin rectangular wafer of high-purity indium arsenide with 4 leads attached.

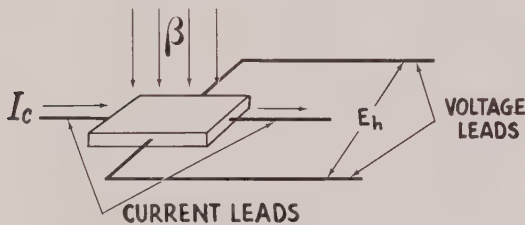


Fig. IV-1 - Sensing Element

The control current, I_c , passes through the long dimension of the element. When placed in a magnetic field some of the charge carriers are deflected across the crystal resulting in the Hall voltage, E_h , appearing across the voltage leads. This voltage is directly proportional to the control current and the magnitude of magnetic flux vector which is at right angles to the face of the crystal.

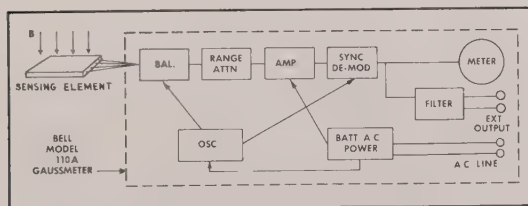


Figure IV-2 - Block Diagram

IV-3 CIRCUIT OPERATION

A. INPUT - ATTENUATOR SECTION

The oscillator section (described later) feeds a half-wave 5KC control current I_c of about 100 ma peak to the probe sensing element.

Under zero field conditions the probe should have zero output voltage if perfectly balanced. Manufacturing tolerances, however, require that a balancing network be provided (the zeroing knobs) to reduce the signal to essentially zero. In the presence of a D.C. field the sensing element is unbalanced as a result of the Hall-Effect and a 5KC signal voltage is developed across the crystal which is proportional to the magnetic field strength B in gauss. An A.C. field produces a signal composed of sidebands on either side of the 5 KC carrier, which is suppressed. This signal voltage is applied through a special balanced input transformer to the RANGE switch attenuator, a precision current divider, to the input base of the first transistor.

B. AMPLIFIER - DEMODULATION SECTION

The amplifier consists of four stages of common emitter current amplifiers followed by a common collector output stage. The first two stages are direct coupled to reduce circuit components as well as to provide current stabilization by D.C. feedback. The last three stages are likewise direct coupled and have an additional A.C. feedback path including a variable resistor for gain control. A.C. signal feedback is also included in the first stages to reduce the impedance at the amplifier input so as to be a negligible factor in the range attenuator step ratios.

The amplifier output feeds the synchronous demodulator which consists of four matched diodes in a bridge circuit.

The diodes are excited by the oscillator signal and act as switches alternately opened and closed across the amplifier output at a 5KC rate. The switching signal fed to the diode bridge is balanced out and does not indicate on the output meter. The 5KC switching voltage fed to the demodulator is phased with the 5KC probe signal current I_c , so that the diode gate is opened when the I_c signal is being fed to the probe. The resulting amplified signal is thus rectified and the D.C. component indicated on the meter. It is also filtered in a two stage R-C network and fed to the output terminals.

C. OSCILLATOR SECTION

The oscillator is a modified and degenerated colpitts in which the inductive portion of the L-C tank is the driver transformer. The oscillator is capable of excellent sine wave form and stability. This signal is fed to a push-pull class B power amplifier stage working at maximum efficiency. A thermistor-resistor network compensates for the temperature loading effect to stabilize the oscillator output level up to about 150° F.

The power stage in turn feeds the 5KC signal into both the synchronous demodulator and, at low impedance, to the switching transistor and then to

the control current I_c circuit.

A 1 ohm resistor in this circuit provides the metering signal for the I_c check and for the CAL voltage used in the self-calibrating feature.

The switching transistor acts as an extremely low impedance diode in the forward direction and high impedance in the reverse direction, i.e., a highly efficient switch. The oscillator, therefore, feeds current to the Probe (I_c) and to the demodulator on alternate half cycles. Impedance relations are designed to equalize these loads for most efficient use of battery power.

SECTION V MAINTENANCE

V-1 INTRODUCTION

The Model 110A should require very little maintenance with the exception of battery replacement and perhaps probe replacement as a result of careless handling.

The transistors used have inherently long, trouble free life. Other components such as electrolytic capacitors are high quality, low-leakage types made especially for transistor circuit use. They are hermetically sealed and rated for operation to 85°C. Other capacitors are mylar film types, potentiometers are all wire-wound units.

Transistors are soldered-in, and special precautions must be observed in removing them because soldering temperatures can permanently damage a transistor. Do not replace transistors unless there is a definite indication that they are faulty, usually another component, solder joint, frayed wire, etc. is to blame. Use long nosed pliers to grasp the transistor leads between the soldering iron and the transistor body to act as a heat-sink. Allow to cool before turning the unit on.

Use care when trouble shooting not to short out bias resistors or short voltages across the transistors which would result in destructive currents through the transistors.

The schematic circuit diagram should prove helpful in servicing, D.C. voltage levels are indicated on the diagram.

See rear view drawing, Fig. V-1 for location of parts and test points on circuit board.

V-2 PROBE SERVICING

No attempt should be made by the user to repair or modify the probe assembly in any way. As noted earlier, the probe cable is of special design and the terminations in the plug and probe handle are very precisely adjusted at the factory.

V-3 CABINET REMOVAL

Remove the power cord from the side of the unit. Remove the five Phillips head machine screws around the outer edge of the rear panel and remove the panel. This will expose the rear side of the circuit board. Three additional screws on each end of the cover will allow the cover to be removed, if necessary.

V-4 BATTERY REMOVAL (and Replacement)

Batteries may be checked without removing them, but the circuit board should be removed from its supporting brackets to get at the batteries for removal. To do this, remove four Phillips head screws at the four corners of the circuit board. Do not over-spring the battery clamps at the ends where the contact lugs are located. To do so will reduce contact pressure and result in intermittent contacts.

NOTE: For best stability, batteries are pre-aged by F. W. Bell before use. Replacement batteries

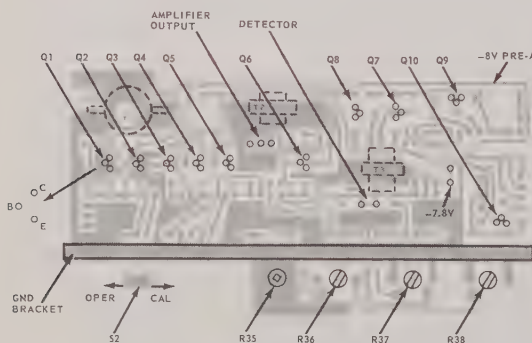


Fig. V-1 - Chassis Layout (rear view)

should be discharged 8-10% of life by connecting a 400 ohm resistor across battery for 4 hours. When replacing batteries, use care to observe correct polarity. Do not remove the bottom plate screws.

V-5 SUGGESTED PROCEDURE FOR TROUBLE-SHOOTING

NOTE: The circuit board is divided into two basic sections. The amplifier section is on the left half of the board (viewed from rear) and consists of the five transistors and the round can type input transformer. The other half of the board contains the oscillator section, the two upright transformers and the three adjustment potentiometers along the bottom. The heavy metal strip running the entire length of the rear of the board is the common (+) ground from which all voltage measurements are taken.

IMPORTANT—The trouble-shooting procedure given below must be made with the circuit board fastened in position in the mounting brackets or with the heavy metal ground strip on the rear of the circuit board jumpered to one of the supporting brackets.

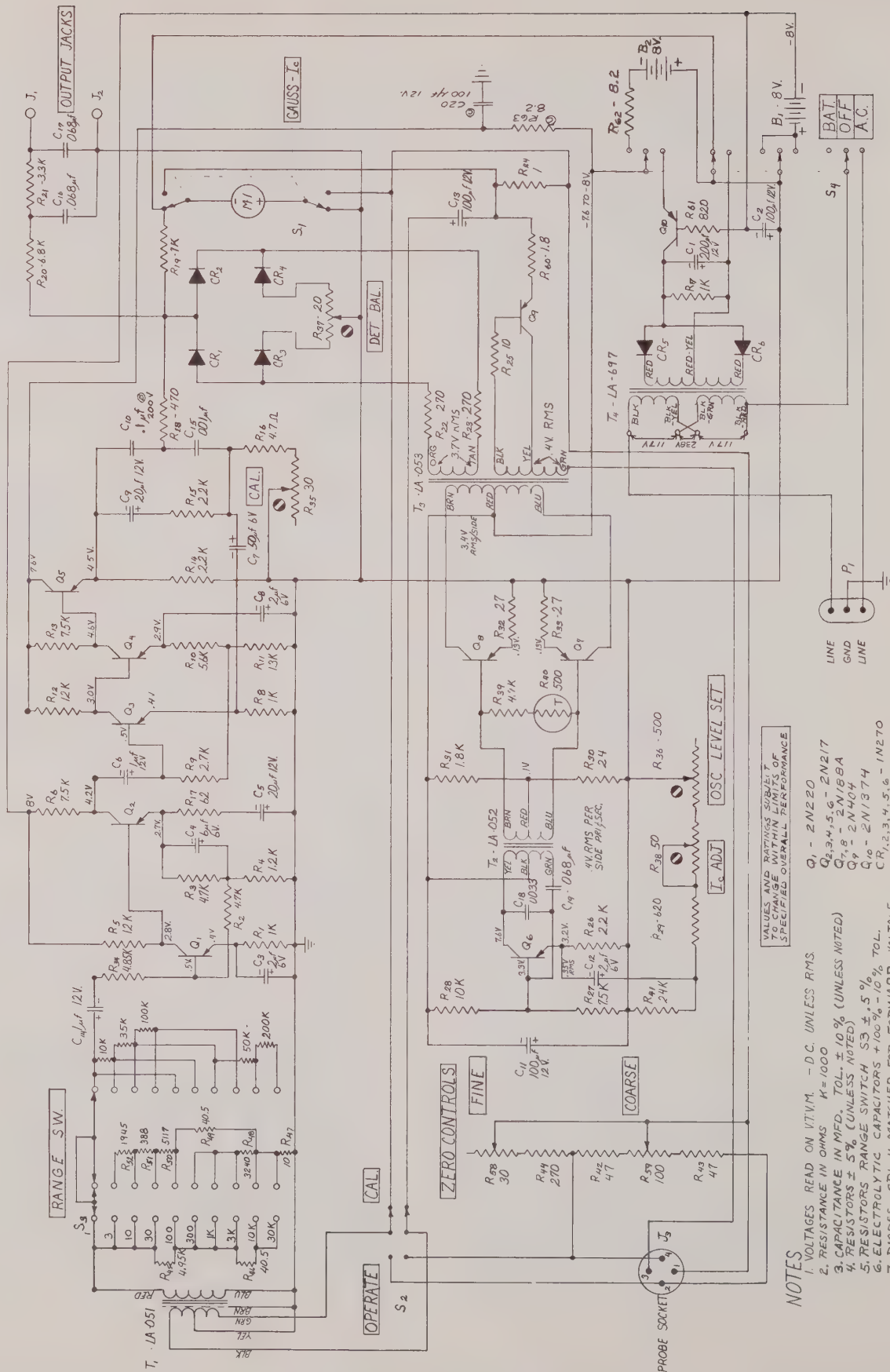
1. Measure the battery voltages (both batteries) under no load conditions — power switch off. They should measure 7.9 to 8.1 volts D.C. on an accurate voltmeter.
2. If the unit is used only on BATT operation the life of B1 will be approximately 1000 hrs. and the life of B2 will be approximately 60 hrs. If the unit is used only on A.C. operation, the life of B1 will again be approximately 1000 hrs. and the life of B2 will be shelf life. The end-of-life voltage of this type of battery is 7.2 volts. Thus a voltage measurement of either B1 or B2 under load (probe plugged in) should not fall below this value.
3. Allow 5 to 6 minutes for stability to be reached, then adjust the control current I_c to a reading of .6 on the upper meter scale. This is the lower extreme right hand adjustment on the board as viewed from the rear (R-38, 50 ohms). A lower than normal reading indicates: (a) exhausted batteries, (b) bad connection in the probe current circuit, (c) fractured probe sensing element, (d) wrong adjustment of oscillator signal level, (e) circuit malfunction in oscillator section, (f) a defective meter.

Failure to obtain any I_c reading at all usually indicates:

(a) probe not plugged in, (b) open circuit in probe current circuit, (c) broken probe element, (d) dead battery or no battery connection, (e) open circuit in meter circuit.

4. Check for correct oscillator operation if test 3 is negative. The correct signal voltage level on the oscillator emitter is about 1 volt peak-to-peak (5KC sine wave) or about .35 volt RMS A.C. This value has been factory adjusted using the 3rd adjusting potentiometer from the right along the bottom (R-36, 500 ohm). Measure with an A.C., V.T.V.M. and readjust only if necessary.
5. Check meter electrical zero on the 30KG range with the probe out of strong fields. Adjust (R-37, 20 ohms) the detector balance adjustment, if necessary, (range switch 30KG position).
6. Check ability to zero meter on the low gauss ranges, with probe out of field. Failure to zero, or drift in the zero reading also indicates a damaged or fractured probe element.
7. Set range switch to the 30KG position and operate CAL switch on rear panel to CAL position. Adjust the CAL (amplifier gain) adjusting screw R-35. It should be possible to vary the meter reading from about .3 on the upper scale to .9 or perhaps full scale. Failure to reach this maximum indicates insufficient amplifier gain due to exhausted battery or other circuit malfunction.
8. Adjust the zeroing knobs on the front panel for full scale deflection on the 10 gauss range. Measure the D.C. voltage at the output jacks. It should measure 100 millivolts within about 10%. A vacuum tube D.C. voltmeter should be used for this test.
9. The A.C. voltage under conditions in 7 should be about 1.5 mv RMS of 5KC ripple.
10. Check the range switch against the meter scales by first adjusting for full scale deflection on the 10 gauss range by means of the zeroing knobs. Now switch to the next two higher range positions, 30 and 100 gauss ranges, and note that the meter reads correctly downscale, within at least one small scale division. Repeat this procedure starting at the 1 gauss range. If the higher ranges check out but the low ranges do not, the amplifier output waveform should be checked for drastic changes on the lower ranges which could indicate inductive unbalance in the probe or input socket wiring, or other stray coupling problems. These are best analyzed by returning the Gaussmeter complete with probe to the factory for servicing.

NOTE: The wires leading to the probe connector socket have been carefully positioned for minimum inductive coupling. Use care not to disturb these wire positions.



NOTES

1. VOLTAGES READ ON VTVM, -DC UNLESS RMS.
2. RESISTANCE IN OHMS $H=1000$.
3. CAPACITANCE IN MFD, TOL. $\pm 10\%$ (UNLESS NOTED).
4. RESISTORS $\pm 5\%$ (UNLESS NOTED).
5. RESISTORS RANGE SWITCH $S3 \pm 5\%$ TOL.
6. ELECTROLYTIC CAPACITORS $\pm 100\%$ - 10% TOL.
7. DIODES CR1-4 MATCHED FOR FORWARD $10\mu A-E$.

VALUES AND RATINGS SUBSTITUTED
SPECIFIED OVERALL PERFORMANCE

- Q1 - 2N220
Q2, 3, 4, 5, 6 - 2N217
Q7, 8 - 2N168A
Q9 - 2N404
Q10 - 2N1574
CR1, 2, 3, 4, 5, 6 - 1N270

SECTION VI

PARTS LIST

FOR

MODEL "110A" GAUSSMETER

Abbreviations

CER	Ceramic	MME	Miniature Mylar Epoxy Coated
Comp	Composition	MT	Mylar Tubular
DEP	Deposited Carbon	PC	Printed Circuit Board
DM	Dipped Mylar	pf	Pico Farad or 10^{-12} f (mmf)
EC	Elektrolytic, Metal Can	PMC	Paper, Metal Cased
EM	Elektrolytic, Miniature	PMT	Paper, Molded Tubular
ET	Elektrolytic, Metal Tubular	v	Working volts
f	Farad	VAR	Variable
FOP	Factory Adj.	W	Watt
	For Optimum Performance	WW	Wire Wound
h	Henry	μ	Micro or 10^{-6}
K	Kilohm or 10^3 ohms	Ω	Ohm
M	Meg., Megohm or 10^6 ohms	FILM	"Metal" Film

Batteries

Bell
Part Number

B1	8.OV.	Mercury	{ Mallory TR-136R
B2	8.OV.	Mercury	{ Eveready E-136N

Capacitors

C1	200 μ f	12 v	EM	Fixed
C2	100 μ f	12 v	EM	Fixed
C3	2 μ f	6 v	EM	Fixed
C4	6 μ f	6 v	EM	Fixed
C5	20 μ f	12 v	EM	Fixed
C6	1 μ f	12 v	EM	Fixed
C7	50 μ f	6 v	EM	Fixed
C8	2 μ f	6 v	EM	Fixed
C9	20 μ f	12 v	EM	Fixed
C10	.1 μ f	400 v	DM	Fixed
C11	100 μ f	12 v	EM	Fixed
C12	2 μ f	6 v	EM	Fixed
C13	100 μ f	12 v	EM	Fixed
C14	1 μ f	12 v	EM	Fixed
C15	.001 μ f	200 v	MME	Fixed
C16	.068 μ f	200 v	MME	Fixed
C17	.068 μ f	200 v	MME	Fixed
C18	.0033 μ f	200 v	MME	Fixed
C19	.068 μ f	200 v	MME	Fixed
C20	100 μ f	12 v	EM	Fixed

Diodes and Rectifiers

CR1	IN270
CR2	IN270
CR3	IN270
CR4	IN270
CR5	IN270
CR6	IN270

Jacks

J1	OUTPUT BANANA (RED)	
J2	OUTPUT BANANA (BLACK)	
J3	INPUT	YA-635

Meters

M1	50-0-50MV F.S.	MA-092
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Transistors

Q1	2N220
Q2	2N217
Q3	2N217
Q4	2N217
Q5	2N217
Q6	2N217
Q7	2N188A
Q8	2N188A
Q9	2N404
Q10	2N1374

Resistors

R1	1K	1/2W	5%	Comp	Fixed
R2	4.7K	1/2W	5%	Comp	Fixed
R3	4.7K	1/2W	5%	Comp	Fixed
R4	1.2K	1/2W	5%	Comp	Fixed
R5	12K	1/2W	5%	Comp	Fixed
R6	7.5K	1/2W	5%	Comp	Fixed
R7	1K	1/2W	5%	Comp	Fixed
R8	1K	1/2W	5%	Comp	Fixed
R9	2.7K	1/2W	5%	Comp	Fixed
R10	5.6K	1/2W	5%	Comp	Fixed
R11	1.3K	1/2W	5%	Comp	Fixed
R12	12K	1/2W	5%	Comp	Fixed
R13	7.5K	1/2W	5%	Comp	Fixed
R14	2.2K	1/2W	5%	Comp	Fixed
R15	2.2K	1/2W	5%	Comp	Fixed
R16	4.7Ω	1/2W	5%	Comp	Fixed
R17	62Ω	1/2W	5%	Comp	Fixed
R18	470Ω	1/2W	5%	Comp	Fixed
R19	1K	1/2W	5%	Comp	Fixed
R20	6.8K	1/2W	5%	Comp	Fixed
R21	3.3K	1/2W	5%	Comp	Fixed
R22	270Ω	1/2W	5%	Comp	Fixed
R23	270Ω	1/2W	5%	Comp	Fixed
R24	1Ω	1W	1/2%	WW	Fixed
R25	10Ω	1/2W	5%	Comp	Fixed

(continued)

Resistors (continued)

R26	2.2K	1/2W	5%	Comp	Fixed
R27	7.5K	1/2W	5%	Comp	Fixed
R28	10K	1/2W	5%	Comp	Fixed
R29	620Ω	1/2W	5%	Comp	Fixed
R30	24Ω	1/2W	5%	Comp	Fixed
R31	1.8K	1/2W	5%	Comp	Fixed
R32	27Ω	1/2W	5%	Comp	Fixed
R33	27Ω	1/2W	5%	Comp	Fixed
R34	4.85K	1/2W	1/2%	DEP	Fixed
R35	30Ω			WW	Var
R36	500Ω			WW	Var
R37	20Ω			WW	Var
R38	50Ω			WW	Var
R39	4.7K	1/2W	5%	Comp	Fixed
R40	500Ω	Thermistor VECO 25D5			
R41	2.4K	1/2W	5%	Comp	Fixed
R42	47Ω	1W	5%	WW	Fixed
R43	47Ω	1W	5%	WW	Fixed
R44	270Ω	1W	5%	WW	Fixed
R45	4.95K	1/2W	1/2%	DEP	Fixed
R46	40.5Ω	1/2W	1/2%	DEP	Fixed
R47	10Ω	1/2W	1/2%	DEP	Fixed
R48	3.24K	1/2W	1/2%	DEP	Fixed
R49	40.5Ω	1/2W	1/2%	DEP	Fixed
R50	5.12K	1/2W	1/2%	DEP	Fixed
R51	388Ω	1/2W	1/2%	DEP	Fixed
R52	1.95K	1/2W	1/2%	DEP	Fixed
R53	10.3K	1/2W	1/2%	DEP	Fixed
R54	34.7K	1/2W	1/2%	DEP	Fixed
R55	100K	1/2W	1/2%	DEP	Fixed
R56	95K	1/2W	1/2%	DEP	Fixed
R57	200K	1/2W	1/2%	DEP	Fixed
R58	30Ω			WW	Var
R59	100Ω			WW	Var
R60	1.8Ω	2W	5%	WW	Fixed
R61	820Ω	1/2W	5%	Comp	Fixed
R62	8.2Ω	2W	5%	WW	Fixed
R63	8.2Ω	1W	5%	WW	Fixed

RA-096

RA-042
RA-095

Switches

S1	Gauss-I _c	DPDT	Slide	
S2	Operate - Cal	DPDT	Slide	
S3	Range (Assembly)		Rotary	YA-211
S4	Power		Rotary	SA-696R2

Transformers

T1	Input	LA-051
T2	OSC.	LA-052
T3	Output	LA-053
T4	Power	LA-697

SECTION VII

WARRANTY

F. W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof (excluding electron tubes, batteries, transistors and probe sensing elements, which parts are covered by a standard EIA 90-day warranty). This warranty covers instruments which, within one year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F. W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F. W. BELL, INC.,

and F. W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F. W. BELL, INC. instruments.

DAMAGE IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

All shipments of F. W. BELL, INC. instruments should be made via Railway Express or Motor Freight. Always use the original shipping carton and inserts, if possible, or pack the instrument in a sturdy container and surround the entire instrument with two or three inches of excelsior or similar shock-absorbing material.

F. W. BELL, INC.
1356 NORTON AVENUE
COLUMBUS, OHIO 43212
UNITED STATES OF AMERICA

100 PER CENT
RELIABLE
W. 81120

